Stakeholder Perspectives and Information Exchange in AEC Projects

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Introduction

Management of construction projects is mainly about managing people, materials and information. Architecture, Engineering and Construction (AEC) projects bring together a large number of people with various professions and organisational affiliations as well as numerous building components and considerations to attend to. Together, this creates the complexity typically characteristic of AEC projects. Adding to this complexity, the multiple phases of the construction project life-cycle introduce further challenges due to the number of stakeholders involved at each stage that have significantly different individual interests and needs.

The AEC industry is under constant pressure to improve performance and increase productivity. This requires handling and analysing large amounts of information to enable the best possible decisions to be made at all stages during the life-cycle of the building. Handling information, most notably by integrating various information sources and information carriers, is a decisive factor to meet the need for improvements.

Numerous stakeholders are involved in AEC projects. This includes the owners, the executive parties and the users. In addition, there are external stakeholders including regulating authorities and market actors. A stakeholder perspective on project (and asset) management requires understanding the objectives of the various stakeholders. The traditional task-based approach of AEC project management is insufficient, with a high degree of external and/or internal complexity (Aarseth, 2012). Therefore, relationship management has developed as a new branch of project management. This relates to increased awareness of the value of relational competence in project-based industries, especially in innovating projects. Partnering is emerging as a new model that relies heavily on relational competencies (Lampel, 2001). Early involvement of end-users is gaining interest to improve value and usability of buildings in use (Baharuddin et al., 2013) through, for example, modern energy efficient office buildings (Meistad et al., 2013). This is also the experience of the respondents to the survey conducted by the OSCAR project[i] which reported increased value for users and owners when involved in the early planning phase (Støre-Valen et al., 2016; Spiten et al., 2016).

Project execution models are seen as a way to systematically deal with the various stakeholders and their perspectives on a project. Execution models can also be considered as a platform to integrate information and engage people throughout all phases of a construction project.

The challenges regarding information exchange increases with the number of stakeholders involved and with demands for early involvement of end-users. However, tools for digital information handling provide opportunities for better integration of various stakeholder objectives and to improve value for owners, operators and end-users. Existing execution models are being challenged by digital developments and the AEC industry has yet to fully explore their potential. A stakeholder perspective can be a guide for further exploring digital information handling within these models for the benefit of public and private assets.

This chapter will first explore the concepts of information integration, execution models and stakeholder perspectives. Four case projects are then used to showcase attempts to increase the level of information integration and strengthen project execution in construction projects. The following sections then explore opportunities and challenges of systematically managing construction projects. These sections have a special focus on how the various stakeholder perspectives can be integrated and how digital information carriers can contribute to decision points (stage gates) throughout the project phases (life-cycle). Finally, the chapter concludes by providing suggestions for future research and investment priority areas.

Information integration and execution models

The word “integration” can have different meanings when related to building and construction industries (Gielingh and Tolman, 1991):

1. Integration of building and construction processes;
2. Integration of construction technologies;
3. Integration of information technology components; and
4. Integration of data or information.

Information integration across project phases and across organisational and professional borders is one of the core issues of project management, possibly the most important one. Within this context, execution models are systems that meet the first meaning of “integration” on Gielingh and Tolman’s list, as they are used to coordinate information and to ensure control over the product quality and the schedule. Integration of data or information, however, forms the basis for all the other types of integration, including integration of building and construction processes (Gielingh and Tolman, 1991), and is one of the building blocks of execution models.

Integrated design and delivery solutions (IDDS) have been used in manufacturing and service industries to improve the quality of production and to deliver complex new products and services (Owen et al., 2009). The construction industry has developed a variety of such approaches, namely the so-called “integrated design process” (IDP). This process was introduced mainly to meet the challenges of designing sustainable buildings. IDP is described as a collaborative process that focuses on the design, construction, operation and occupation of a building over its complete life-cycle (Larsson, 2002). The process includes the client and other stakeholders, and allows the development and realisation of functional, environmental and economic goals and objectives. IDP and IDDS cover all the meanings of integration suggested by Gielingh and Tolman.

Integrated energy design (IED) is a type of IDP that focuses on environmental sustainability and energy efficiency. The methodology emphasises the importance of integrating information and engaging all relevant stakeholders during the concept and design phases. This focus on the early phases of a project is based on the understanding that the costs associated with changes increase as the project progresses, while the ability to affect the outcomes decreases in later life-cycle phases.

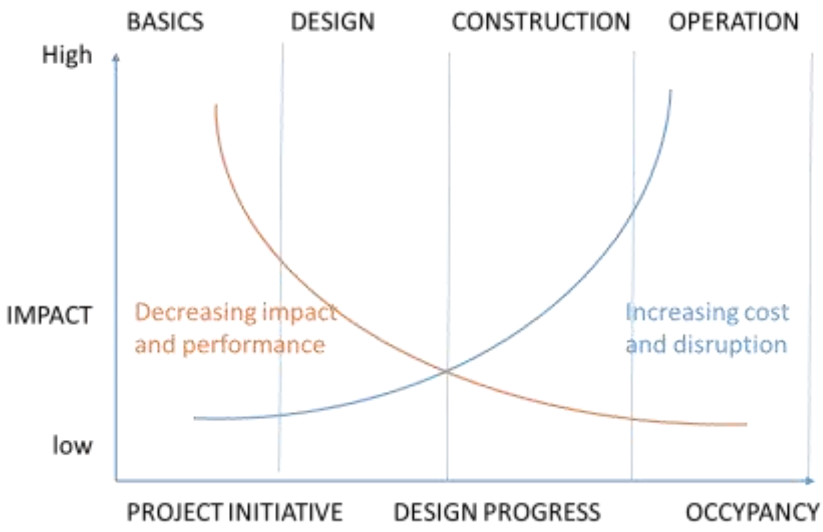

Figure *1*: Integration in early phases offer opportunities for large impact on performance. (Figure based uponAndresen et al , 2005)The methodology focuses just as much on the social process for integrating knowledge and expectations among the parties as on optimising energy efficiency, architecture and cost efficiency of the building concept (Hestnes and Andresen, 2009). In these early planning phases, the focus is on what the clients want. Dialogue between design teams and the owners, operators and users is therefore essential to the process. Andresen et al. (2005) summarise the process in the following nine steps:

1. "Select a multidisciplinary design team from day one, which are skilled in energy/environmental issues and are motivated for close cooperation and openness;
2. Analyse the boundary conditions of the project and the client's needs and demands and formulate a set of specific goals for the project;
3. Develop a Quality Assurance Program and a Quality Control Plan to that is implemented throughout the project;
4. Arrange a kick-off workshop to make sure that all team members have a common understanding of the design task;
5. Facilitate close cooperation between the architect, engineers and relevant experts through co-localisation or through a series of workshops during concept design phase;
6. Update the Quality Control Plan and document the energy performance at critical points (milestones) during the design;
7. Develop and implement contracts that encourage integrated design and construction.
8. Motivate and educate construction workers, and apply appropriate quality tests;
9. Make a user manual for operation and maintenance of the building" (Andresen et al 2005, p 18).

By contrast, Samset (2010) suggests monitoring projects at two levels: tactical and strategic. The tactical level deals with cost, time and quality as success indicators for a project. The strategic level looks at effect, relevance and sustainability indicators when considering project success. Different stakeholders can be interested in the strategic or tactical level, depending on their role in the project. The owner is typically most interested in the strategic performance of the project, while the executing parties tend to limit their interest to the tactical performance.

Execution models are tools used in project management to coordinate information and to ensure control over the product quality and the schedule. Traditionally execution models are understood as consisting of 1) enterprise form, 2) contract form, and 3) procurement form (Lædre et al., 2006; Løkkeberg, 2015). In simpler words, project execution models can be defined as “the way we work and deliver projects”. These models normally present projects as a series of phases, each of which has a clear purpose and defined roles for the stakeholders involved. The handover from one phase to the next is critical to the flow of information in the project. The work of each phase leads to a point of decision whether to proceed or not, sometimes referred to as a stage gate (Knotten et al., 2016b). Each shift of phase is also a handover of information to the parties/enterprises responsible for the next phase. Ensuring the relevant information is handed over at the appropriate time is therefore a key issue for project management professionals. The constant drive to improve information flows, quality and productivity leads to project execution models being continuously developed to adapt to changes in regulations and market expectations.

Traditionally, due to competition and procurement rules, there has been adversarial interactions between execution parties, and projects have been negotiated as a zero-sum game. Information integration is an alternative approach for project management that highlights the overall purpose of the project. By letting professionals get together and analyse various information sources, the process allows them to develop innovative solutions that would not have emerged from an adversarial process (Lampel, 2001).

Stakeholders as information integrators and their perspective

There are two basic approaches to exploring the issues related to integrating information during project execution, depending on the type of information carrier that is of interest: *the people* handling the information or the *physical carrier* of the data. The interest around information integration has been driven by technical developments, especially the ongoing revolution of digital information handling. IDP and IDDS register and exploit a large amount of data in the search for optimal logistics and project solutions. Less explored, however, is the guidance that IDP and IDDS provide for facilitating team-building and high-performance attitudes.

Independent of the physical information carriers, it is the people that are the information integrators. This includes the client, other project parties and the users, all of whom are often labelled “stakeholders”. This chapter will explore the role of the various stakeholders during project execution and the challenges associated with integrating information across the various perspectives of the many stakeholders involved in the different life-cycle phases of a built asset.

Three major groups of stakeholders are involved during the various phases of a construction project, each bringing their own point of view. Samset (2010) refers to these points of view as perspectives and lists them as owner perspective, user perspective and executing perspective. The owner is the initiating and financing party; owners normally have a long-term interest in the investment that the project represents. The user is the party who is going to utilise the end result (the building) to operate their business. The executing party, or parties, is formed by the architects, engineers and contractors who will be executing the project on behalf of the owner.

Four research projects: Learning across trades, parallelism, scan-to-BIM and Next Step

Project management requires the above-mentioned perspectives to be identified and managed. Knotten et al. (2016a) suggest identifying them at an early stage to understand the various focal points and to coordinate or possibly change the attitudes regarding purpose and success of the project. Mejlænder-Larsen (2016) further suggests identifying drivers to secure alignment to common goals in the project team. The following case studies will show different approaches to dealing with the challenges brought by these differing perspectives.

The first case study compares the AEC industry with the shipbuilding and offshore construction industries. In this case, varying perspectives are handled by implementing a higher degree of standardised designs, predefined interconnections between parts of systems and use of in-house design teams. The second case study explores how general contractors are able to handle parallelism between these two phases and thereby shorten the timeframe of construction projects. The third case study, based on Hjelseth et al. (2016), focuses on the facility management perspective and explores the use of Building Information Modelling (BIM) for multiple purposes by different stakeholders in the in-use phase of buildings. This case discusses topics such as information integration for existing buildings, decision processes and usefulness of scan-to-BIM for the purpose of asset management. The final case study provides a new systematic approach to plan and execute AEC projects, clarifying phases and roles throughout the life-cycle of a building construction project (Knotten et al., 2016a). All four cases are based on research carried out in Norway and represent front-end research on current challenges for the Norwegian construction industry.

Improving the design phase of AEC industry projects – Learning across trades

The design phase is crucial for value creation in a project. A major question for the AEC industry today is whether it can improve this phase by using insights and practices from other industries. This question was explored by Knotten et al. (2016a) in a comparative study of design management in shipbuilding, offshore construction and the AEC industry. The study explored the characteristics of some of the key processes in these three industries.

Shipbuilding (SB), offshore construction (OC) and AEC are project-based industries. Unique products are designed and manufactured for different customers, and there is a high level of complexity. These similarities make the comparison of these three industries possible and useful in understanding the lessons that can be learned across sectors. The comparison revealed that design processes vary between the industries, especially regarding reciprocal and sequential processes. Figure 2 shows a comparison of the design process in the three industries, highlighting individual characteristics that lead to differences in the design process and management.

[KH1]

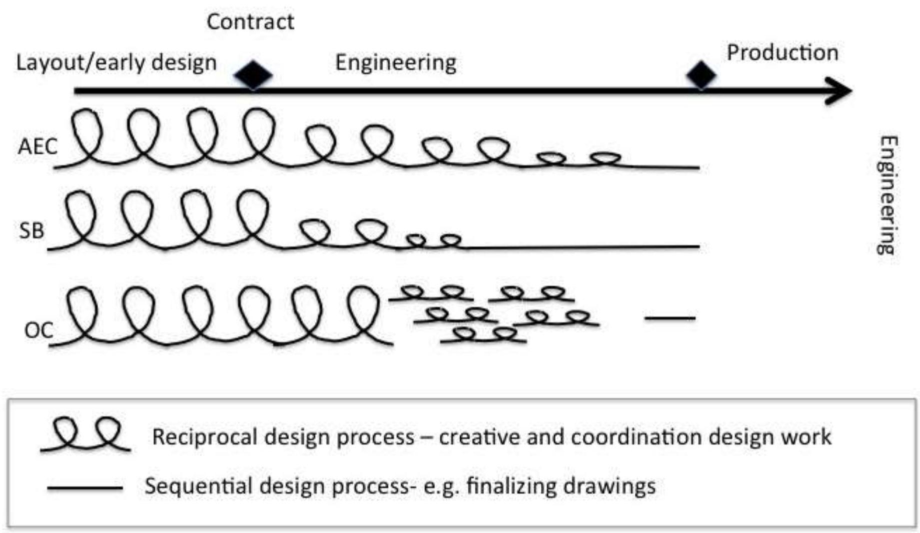

Figure 2 : Design process in different trades. (Source: Knotten et al., 2016a)

The design process is more standardised in shipbuilding than in AEC. This allows shipbuilding designers to often use previous designs as a starting point, adjusting it to the client's requirements. The engineering process is often parallel between design and production, narrowing the options of change as the parts are finished. The engineering team consists of in-house personnel, though they can be located in multiple offices. The planning of engineering is based on delivering drawings to the production office. This is monitored by a computerised planning system linking working hours to drawings. However, this process does not monitor the value-creation processes.

Offshore construction companies deliver parts of larger production systems. Therefore, there are a lot of predefined interfaces in space, weight and technical requirements. Offshore construction companies have their own design teams and their members remain the same throughout the whole design process. This ensures that the knowledge gathered in the early design phase is carried through the whole design process. Moreover, to ensure that the knowledge from construction is brought into design, key members of the construction team are engaged during the early design phase. The in-house team also shares the same organisational culture. This ensures that their work is aligned with a single set of organisational and project goals and is based on pre-existing trust between the team members.

In offshore construction, the design phase follows a stage-gate model with clear deliverables at each stage. Key members of the design team agree on the maturity level needed to proceed to the next stage. The designers use BIM as a main tool for design. When the correct maturity level is reached in an area of the model, that area is "frozen" and no further interdisciplinary changes are possible. The finished model has to be approved by the client before detailed drawings are drawn in 2D.

The three industries are similar in that the design and engineering services are required to transform the needs of clients and users into a finished product. However, the complexity of the products, processes and context varies between them. While the contractors in the AEC industry to a large extent do not use their own design team, this is more common in offshore construction and shipbuilding. The AEC industry also does not often operate from a common production site and prefabrication is limited. Offshore and shipbuilding on the other hand, use a common production site and prefabrication is the norm.

While all three industries have reciprocal design processes after contract, the offshore construction industry process is divided into smaller concrete tasks and finalising the drawings is a sequential process. The AEC industry can learn from this by implementing planning and execution methods used by offshore construction. Of special interest is the new way of planning and executing engineering that the offshore construction industry has implemented, thus exploiting more of the benefits of BIM. "By producing production drawings at the last responsible moment, they let the coordination process last longer, leaving time for the design to evolve and mature" (Knotten et al., 2016a).

Parallelism between phases

Parallelism, or concurrent engineering and construction, is gaining popularity due to the increased demand for shorter project timeframes. However, it presents greater challenges for contractors to control the work and the extent of the challenge depends on the client's requirements. The client sets the scene in terms of how complex the process becomes, in part by setting the timeframe from the signing of the contract to the delivery date. While longer timeframes allow for more predictability between phases, shorter timeframes allow a higher degree of parallelism between the phases. The more parallelism there is in a project, the greater the demands put on the participants.

In offshore construction, Engineering, Procurement and Construction (EPC) contracts are common. In EPC contracts, construction is often pushed in parallel with engineering services. This parallelism is a challenge for information integration due to the need to ensure that the drawings and materials are available when they are needed.

Mejlænder-Larsen (2016) presents a case study about a Norwegian EPC contractor. This company developed a building sequence where the engineering phase is divided into stages with corresponding milestones (see M2A-C in Figure 3). At the third milestone, the engineering sub-contractor reach a defined quality level to start issuing drawings from BIM so that construction can start. Engineering influences all project phases and is developed to a quality level where the design and all interfaces between disciplines are frozen. “Engineering for procurement” is then developed during the procurement phase and “engineering for fabrication” is developed in the construction phase (Kvaerner, 2012; 2013).

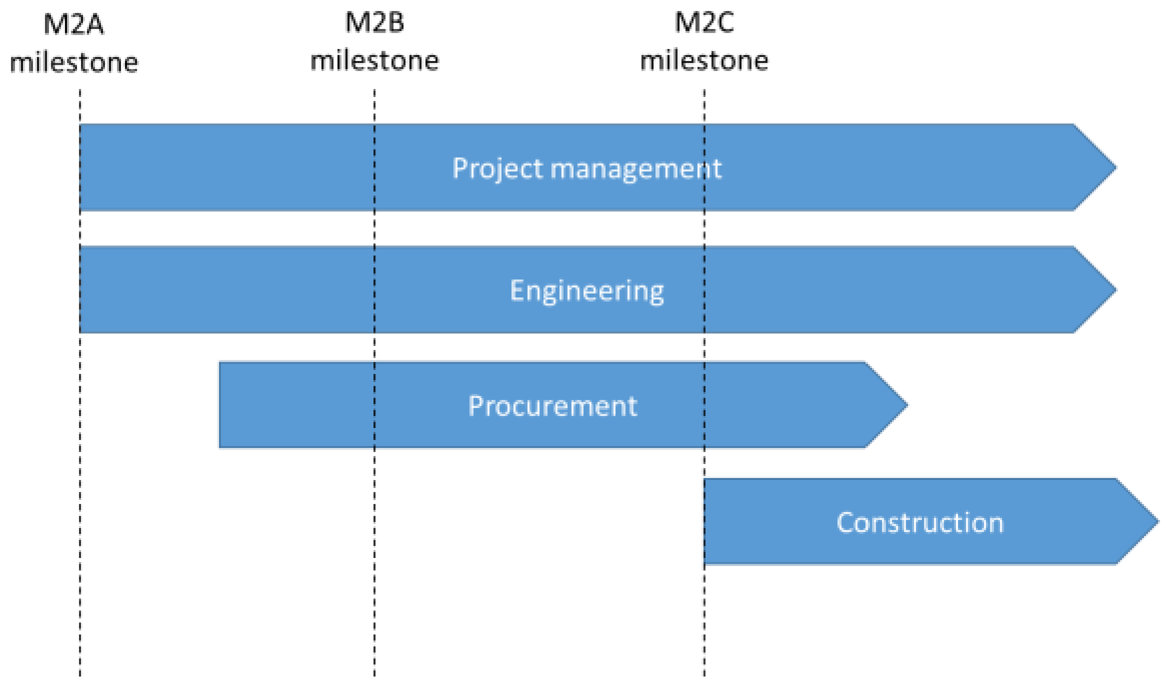

Figure 3: Parallelism between engineering, procurement and construction. (as published by Mejlænder-Larsen (2016))

The ambition of the EPC contractor is to get the work “Right the first time”. For this purpose, a project execution model (PEM) was developed, where progress and quality requirements were aligned at the relevant milestones. The first requirement for being able to govern construction projects according to this model, is that the PEM uses a standard methodology which is well known to the team. Secondly, common incentives and drivers are required, including the possibility to use a joint venture between the engineering sub-contractor and the EPC contractor. Thirdly, it requires the utilisation of technology, including a 3D design environment such as BIM, to support a desired build sequence for the EPC contractor. Accurate lead times for equipment and timely availability of correction vendor information are critical to efficient fabrication assemblies. The EPC contractor’s building sequence is an example of how defined milestones can be used to better integrate information between engineering and construction teams. There is, however, a need to better understand this process, the people involved and the technology in use before this execution model can be leveraged to its full potential by the built environment industry.

Scan-to-BIM for the in-use phase

This section presents a case study based on a scan-to-BIM test project. The study carried out by Hjelseth et al. (2016) explored alternative technologies for 3D scanning and modelling, and collaboration between project stakeholders to establish a BIM model for the purpose of facility management of an old apartment building. The execution model suggested for management of the scan-to-BIM process is based on a step-by-step process framework for ordering scan-to-BIM services. The framework combines relevant technology, processes and human resources.

Hjelseth et al. (2016) present an ordering guide as a starting point for buyers ordering a scan-to-BIM service and seeking to receive the best cost–benefit ratio possible. This includes three steps:

1. Establishing a development plan that focuses on collaboration. This plan outlines those stakeholders who have vested interests in the project and those who should have access to the resulting model.
2. Developing an overview of the different challenges faced by the collaboration team and how BIM can be used as a tool to solve these issues. One of the questions this addresses is what level of accuracy is required for the data capture.
3. Integrating the measurements into a BIM model. This can be a simple volume model, a volume model with standard objects added, or added attributes and relations to get a full BIM model. The full BIM model version is more useful but also more expensive.

Further, Hjelseth et al (2016) focus on the process from the decision to capture geometrical data about the building to establishing a BIM model for one or more purposes. This process includes three main steps, namely scanning, BM-ing and BIM-ing, as illustrated in fFigure 4.

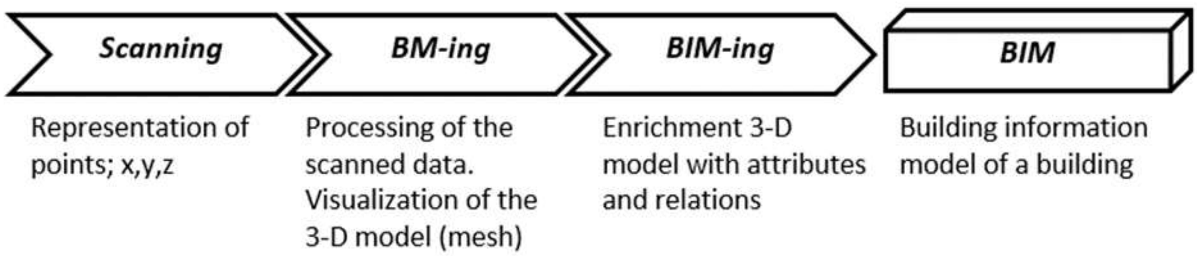

Figure 4: Main stages in the scan-to-BIM process. (Source: Hjelseth et al, 2016)

There are various instruments for capturing geometrical data (scanning in Figure 4). Technology not only includes the physical data-collection devices but also the software required for processing and enriching of scanned data (this is referred to as BIM-ing in Figure 4). Most software packages are plug-ins into typical architectural design authoring software.

The result from the test project was good. The board of directors of the managing organisation wanted to use BIM as a tool to link the maintenance history, day-to-day status and scheduled maintenance directly to building objects in the model. The existing drawings were old and inaccurate. The BIM model can be used for area calculation and was shown to be a good starting point for establishing a maintenance plan (Direktoratet for byggkvalitet, 2015).

This test project reveals that there are a number of technologies available, both hardware and software, and that digital information integration provides better decision support for existing buildings. The 3D presentation is good for communicating information to the various stakeholders and is supportive for shared decision-making on operation and maintenance. The study reveals the challenge of selecting the most suitable level of data accuracy, and provides a guide to find the level of details (and costs) matching the purpose of the scan-to-BIM.

"Next Step" – A new systematic execution model

How can one ensure that decisions are made at the right time and at the right organisational level? This is a basic challenge for project management. Norwegian construction industry and researchers have been working together over the last couple of years to develop a systematic approach to overall project management. The new framework, called Next Step, identifies the key steps and tasks in a project life-cycle from the definition to the termination of the building. The framework focuses on project execution, critical decisions at a corporate level, involvement of the proper stakeholders' perspectives and sustainable development of the AEC industry.

The eight steps of the project are indicated at the top of Table 1. Each step has a clear purpose and together they cover all the different phases of a project. Termination can refer to the termination of ownership, where the owner sells the property, or the demolition of the building in order to utilise the site in a different way.

Table 1: Outline of the Next Step framework. (Source: Knotten et al., 2016a)

Step	**1** **Strategic definition**	**2** **Brief development**	**3** **Concept development**	**4** **Detailed designing**	**5** **Production**	**6** **Handover**	**7** **In use**	**8** **Termination**
Core process	**Owner** perspective							
	User perspective							
	Supplier perspective							
	Public perspective							
Management process	Planning							
	Procurement							
	Communication							
	Sustainability - economics							
	Sustainability - environment							
	Sustainability - social							

Next Step is inspired by the RIBA Plan of Work (Royal Institute of British Architects, 2013). The framework is based on a systems thinking approach that includes input, process and output logic as well as creating decision gates after each step. An output can become the input of the next step or lead to the termination of the project. The process includes the actual tasks that need to be completed in order to advance the project (Klakegg et al., 2010).

Next Step is also based on the principles of "project governance" (Klakegg et al., 2009; Müller, 2009) and advocates a structure of clearly defined phases in construction project processes. It has a special focus on decision gates at the end of each phase before handing over information and tasks to the team(s) in the next phase(s). The gateway is a key element of an adequate implementation strategy. The purpose of a decision gate, as seen from a project owner's perspective, is to make sure the formal decision-making supports the success of the organisation, business corporation or public entity. Ensuring the right decisions are made requires decision-makers to be as informed as possible. However, the right information is a question of what is available, or known at the time, versus the cost of obtaining more/better information and the risk associated with making the decision based on less-than-perfect data. Decision gates are often characterised by having defined procedures for assessments, control and decision-making; defined roles and responsibilities; criteria for acceptance and a gatekeeper (owner of the gateway process) who decides whether the project is allowed to (enter) pass the gateway and continue to the next step or not.

The framework divides the processes into two major categories: Core and management processes. The core processes deal with the perspective of four stakeholders: The owner, the user, the executor and the public. All these perspectives have to be dealt with to ensure that the different mindsets are integrated in both the input (requirements) and output (deliverables) of the project. The management processes include planning, procurement, communication and the economic, environmental and social aspects of sustainability.

The purpose of the model is to facilitate stronger governance of construction projects and its focus is on clarifying the phases and the stakeholders related to each phase. The decision gates are a key concept in the model. Control of documents and assumptions must be made before making a decision to accept a project or to close one phase and enter the next.

Each decision gate is seen from different perspectives by the various stakeholders. For owners, a decision point is a time for them to look forward and focus on how the project can support the success of the business corporation, public entity or user organisation. From the construction team's perspective, predicting or proving whether the project is an economic success may be a milestone.

The intention of Next Step is to give the industry a common language and a collective reference for AEC projects. Next Step can help achieve success for owners and users by defining the necessary steps for going from a problem to a solution. The framework forces the parties to consider the long-term issues and to holistically assess sustainability of alternative concepts. The right choices are expected to become the natural outcome from such a process. The new framework/general standard is expected to improve planning and control of project executions by providing a step-by-step system that eliminates non-conformance and miscommunication compared to a model where each company uses their own execution model. However, it may take time for the many actors involved in the AEC industry to approve the model and change their practices.

Concluding remarks

Expectations are high, but the process of developing and deploying systems for information integration within the construction industry suffers from a series of problems or challenges, including the following (Shen et al., 2010):

- It is difficult to access accurate data, information and knowledge in a timely manner in every phase of the construction project life-cycle.
- Conventional programme plans and designs are optimised for a limited set of parameters in a limited domain; the capability to support "total best value" decisions does not exist.

- Life-cycle issues are not well understood and therefore modelling and planning do not effectively take into account all life-cycle aspects such as operations, maintenance and environmental impact.

The first three case studies presented in this chapter highlighted two dominating approaches to information integration:

1. Refine and improve existing project management systems; information technology is a tool to support the overall process.
2. Explore the potential gains from using information technology for various purposes in the construction industry in order to improve performance and quality.

In both approaches, the use of technology for information integration is a helpful tool for decision-making. Hjelseth et al. (2016) expect BIM for existing buildings to become more relevant with the increasing number of solutions available to combine technology, processes and human resources. They suggest breaking down the overall process into small work packages or services that can act as options for further processing and enabling of new purposes. An outcome of this approach can be add-on services that enable the reuse of previous work. This can result in extended use of BIM for multiple purposes in asset management.

Followed by facility managers, clients have the most to gain financially from implementing BIM during the operation phase. A study of BIM users published in 2013 demonstrated that collaboration aspects have the highest positive impact on the success of the implementation effort, followed by process aspects and finally software aspects (Eadie et al., 2013). In 2004, a US study concluded that inadequate interoperability across all life phases of facilities resulted in efficiency losses for the whole industry, and especially for owners and operators (Gallaher et al., 2004). The ongoing digital transformation provides tools to manage and communicate product and project data between stakeholders and throughout life-cycle phases, and thereby to improve interoperability. 3D design and just-in-time management tools provide benefits not only for cost, time efficiency and quality (the tactical level), but also for responsiveness, further investments and other strategic issues (Sanchez et al., 2016).

The design phase is crucial for value creation in the project. Typically, the AEC industry is characterised by a strong sequential mindset which influences design management (Knotten et al., 2014). Here, it has been suggested that using reciprocal design processes will help to overcome the barriers between phases and professionals, and to improve the potential value of the project. Such reciprocal processes are well recognised in theory but only implemented in the AEC industry to a limited degree. This relates to risks and challenges, since they are difficult to plan and manage (Hansen and Olsson, 2011).

Further research is needed to understand how information integration can be used as a tool for improving the overall value of the project, especially the strategic level, and dealing with effect, relevance and sustainability. The social aspects of information integration also need to be investigated, in particular the dialogue between stakeholders, exchange of perspectives and expectations, and the potential to explore options that maximise performance and reduce costs simultaneously. Finally, research is also needed about how information integration technology can be used as a tool for innovation and whether standard information systems support or hamper creativity and learning for industrial development.

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